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Floating Solar Photovoltaic (FSPV) Systems: Current Trends, Advancements, and Challenges

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ABSTRACT

The growing energy demand in the current era has driven the need to adopt renewable energy sources. Among these, solar energy stands out as a promising solution to meet the rising energy requirements. This paper presents a review of existing floating solar power plants around the world, focusing on their capacity. Floating solar plants offer the advantage of conserving land typically required for solar installations.Traditional land-based solar projects often face challenges such as limited land availability, the need for land development and acquisition, substation capacity constraints, power evacuation issues, and delays in obtaining project clearances. These factors can hinder the timely execution of solar projects.Government-identified locations for solar development, based on solar radiation data, are often in hot and arid regions. While these areas receive high levels of solar radiation, the actual energy yield is reduced due to the overheating of solar panels and elevated surface temperatures of the solar cells.To address these issues, an innovative solution has emerged: installing solar panels over water bodies such as canals, lakes, reservoirs, and dam backwaters, which are typically government-owned. This paper presents an in-depth overview of floating solar photovoltaic (PV) power plants implemented across the globe.It highlights the potential of floating solar panels for power generation and minimizing water evaporation.

Keywords: Floating Solar Photovoltaic (FPV) Systems, Floats, Mooring Systems

INTRODUCTION

India's energy crisis poses a serious challenge to the country's development and economic stability. Despite being the third-largest electricity producer globally, the nation continues to face persistent energy shortages. These issues primarily stem from a heavy reliance on fossil fuels, inadequate infrastructure in several regions, and inefficient power transmission systems. Rapid industrialization, urbanization, and population growth have dramatically increased electricity demand, leading to frequent blackouts and power outages across many areas.Addressing this crisis requires a realistic and forward-looking approach. It is now more critical than ever to invest significantly in renewable energy sources, modernize the power grid, and adopt energy-efficient technologies. These steps are essential to ensure a reliable, efficient, and sustainable energy supply for all citizens of India [23].

India receives approximately 5,000 trillion kilowatt-hours (kWh) of solar energy annually, with most regions experiencing solar irradiance levels between 4 and 7 kWh per square meter per day. This vast solar potential makes solar photovoltaic (PV) technology a highly scalable and viable energy solution for the country. Solar energy also supports distributed generation, allowing power to be produced close to the point of consumption and facilitating rapid capacity expansion with relatively short implementation timelines.Decentralized, off-grid systems and low-temperature solar applications offer significant advantages, particularly in rural areas, by addressing local energy demands for electricity, heating, and cooling. These solutions are equally valuable in urban contexts. From an energy security standpoint, solar power stands out as one of the most reliable and secure energy sources due to its abundant and consistent availability across the country [24].

Floating solar power plants offer an innovative and efficient solution to the twin challenges of land scarcity and increasing renewable energy demand. By deploying photovoltaic systems on water bodies such as reservoirs, lakes, and ponds, these systems optimize solar energy generation while conserving valuable land resources. In addition to capturing solar energy, the floating platforms contribute to environmental benefits by reducing water evaporation and limiting algae growth, thereby supporting the ecological health of aquatic ecosystems.The modular and flexible design of floating solar installations allows for scalability, making them adaptable to a broad spectrum of applications—from small-scale decentralized systems to large-scale utility projects. With continuous technological advancements and increasing emphasis on environmental sustainability, floating solar photovoltaic (PV) plants are expected to play a pivotal role in the future of clean energy generation.

Floating solar power plants have emerged as a promising alternative to conventional land-based solar installations, attracting widespread attention for their ability to address critical spatial and environmental challenges. By deploying solar panels on water surfaces, such as reservoirs, lakes, and wastewater treatment ponds, these systems offer numerous benefits—including efficient land use, improved energy generation performance, and reduced ecological disruption.The floating platforms not only enable solar deployment in areas with limited land availability but also provide environmental advantages, such as minimizing water evaporation and improving water quality through surface shading. Their modular and adaptable design ensures flexibility and scalability, allowing them to accommodate a wide variety of energy requirements and site conditions. Moreover, floating solar systems can be customized to comply with local environmental and regulatory frameworks.As technology continues to advance—enhancing both the efficiency and affordability of these systems—floating solar PV plants are poised to play a critical role in expanding global renewable energy capacity and supporting efforts to combat climate change.

Key components of floating solar plants

A floating solar power plant comprises photovoltaic panels mounted on buoyant structures that rest on water bodies such as reservoirs, lakes, or backwaters. These systems present a sustainable and efficient alternative to traditional land-based solar farms, especially in areas where land availability is limited or land costs are high. While functioning similarly to conventional solar panels in converting sunlight into electricity, floating installations offer additional benefits, including reduced water evaporation and enhanced energy efficiency due to the natural cooling effect provided by the underlying water surface.

Floats: These buoyant platforms not only provide robust support for the solar panels but are also designed to withstand fluctuating water levels and harsh weather conditions.High-density polyethylene (HDPE) that is maintenance-free, UV-resistant, recyclable, corrosion-resistant, and has excellent tensile strength, is utilized to make the bulk of floats used in the industry[1]. Fiber Glass-reinforced plastic is another, albeit less typical, material used for floats[2].

PV Module: Crystalline Silicon is the most usually used FPV system module type [3]. Crystalline modules function fine in freshwater settings, but because the industry turns its attention to marine settings, modules must be built to survive the salty conditions. As a result, an alternate material will need to be used in place of traditional metal frames. Indeed, second-generation solar panel technologies such as cadmium telluride (CdTe), amorphous Silicon (a-Si), and copper indium gallium selenide (CIGS) are practical choices for floating PV systems.

Mooring systems: Critical for maintaining the stability of the entire structure, mooring systems use strong anchors and flexible cables to hold the plant securely in place even in strong winds and currents.The mooring lines are commonly made of nylon ropes, enabling the system to adjust to wind and water depth changes. Depending on the project budget, the water depth, the state of the seabed, and other parameters, the anchoring method may be gravity-based, drag embedment, suction, or tension-based. It is essential to consider the longterm performance and dependability of the anchoring mechanism to ensure the safety and stability of the FPV platform in challenging marine environments

Electrical components: A network of high-quality wires, inverters, and transformers ensures seamless energy conversion and transmission, adapting to the unique challenges of water-based installations.

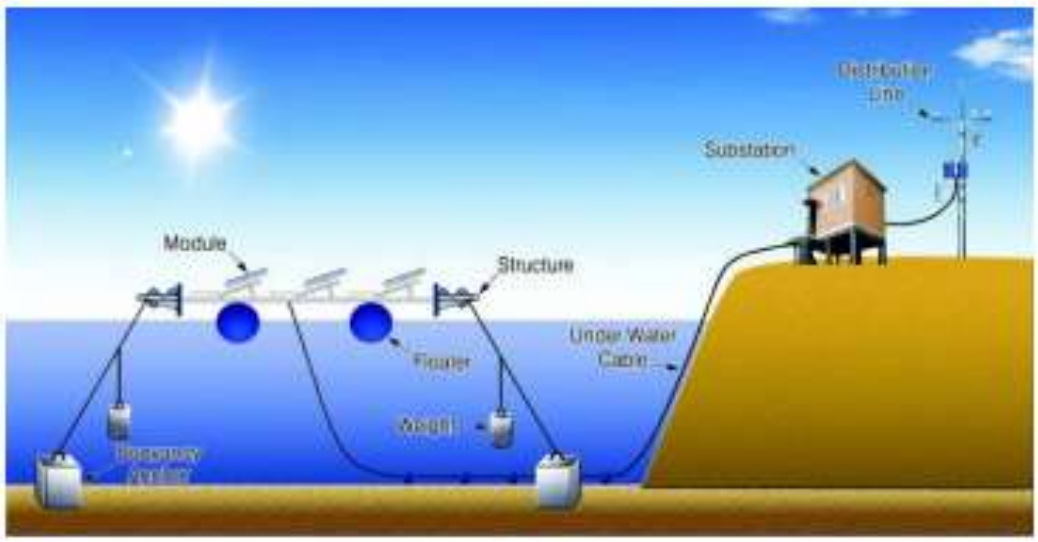

Figure 1: Floating PV Plants Outline [17]

Working of floating solar plants

Floating solar panels introduce an innovative adaptation of conventional solar technology, tailored to meet the specific challenges and opportunities presented by aquatic environments. While the core operational principles are similar to those of land-based solar systems, their design and deployment are optimized to harness the advantages of water-based settings. These advanced systems generate renewable energy through the following mechanisms:

1. **Solar radiation absorption:**Advanced photovoltaic (PV) cells mounted on floating platforms absorb sunlight to initiate energy generation. The reflective properties of the water surface can increase light exposure to the panels, thereby enhancing their efficiency.

2. **Energy conversion:**The absorbed solar energy is converted into direct current (DC) electricity within the PV cells. The proximity to water helps maintain lower panel temperatures, which improves the overall efficiency of the energy conversion process compared to typical land-based systems.

3. **Inverter integration:**The generated DC electricity is transferred to an inverter, where it is converted into alternating current (AC). This step ensures the electricity is compatible with utility grids and standard electrical applications.

4. **Energy distribution:**Once converted to AC, the electricity is either fed into the local grid or used directly to power nearby residential, commercial, or industrial facilities, maximizing utility and minimizing transmission losses.

By utilizing otherwise underutilized water surfaces, floating solar PV systems not only conserve land but also deliver superior energy output thanks to cooler operating conditions and enhanced solar exposure. These systems represent a significant advancement in the pursuit of sustainable and space-efficient renewable energy solutions.

Figure 2: Working of Floating Solar Plants
Source: https://ornatesolar.com/blog/what-are-floating-solar-plants

The PV modules produce DC electricity, which is stored in the combiner boxes
This electricity is then converted to AC current through inverters.
The inverter sends the energy through the cables to mainland.

LITERATURE REVIEW

The advancement of floating solar photovoltaic (FPV) systems marks a notable step forward in renewable energy technologies, offering substantial power generation with limited environmental disruption. Yet, to unlock their full potential, enhancements are needed—particularly in the areas of floatation design, system instrumentation, and monitoring technologies. Overcoming obstacles like safety concerns, lack of standardization, and regulatory issues is essential for broader implementation. Despite these challenges, continued innovation could position FPV as a key contributor to global clean energy production, offering a viable alternative to fossil fuels and supporting the shift toward a more sustainable energy future. Future research should prioritize the development of automated data acquisition and monitoring tools to enhance operational efficiency and data accessibility. Additionally, studies are needed to evaluate FPV's ecological effects, including the impact on ground temperatures and how these might vary across different aquatic environments [4].

Recent reviews on FPV modelling emphasize the pressing need to simulate the behavior of multiple floating modules in wave conditions, which differs significantly from current ocean energy (OE) simulation techniques. A considerable knowledge gap also exists in the design and optimization of FPV mooring systems. While FPV installations have demonstrated some environmental benefits, issues like biofouling and corrosion caused by the surrounding environment remain under-researched and inadequately addressed. Overall, the review offers valuable insights into FPV system development and supports the continued expansion of this technology in aquatic environments [5].

Although floating solar photovoltaic (FSPV) systems offer notable advantages—such as minimizing land-use conflicts and benefiting from water's natural cooling to enhance performance—there remains a significant lack of research on stand-alone, community-focused FSPV setups with integrated monitoring and control capabilities. This gap presents an

opportunity for further technological development aimed at supporting localized energy needs and strengthening resilience to environmental challenges [6].

Looking ahead, it is anticipated that the surfaces of water bodies linked to hydroelectric dams, pumped storage systems, and cooling ponds of power plants—many of which already have grid connections—will be extensively utilized for deploying floating solar systems [7].

FPV technology holds considerable promise for generating renewable electricity while also conserving water resources. However, further studies are needed to evaluate and manage potential environmental effects, particularly in marine settings. From an economic perspective, FPV systems have shown to be a cost-effective solution, especially in regions where land is scarce or expensive. Levelized cost of energy (LCOE) assessments indicate that FPV is not only economically feasible but also a valuable asset in the global transition to sustainable energy and efforts to mitigate climate change [8].

Prof. Shishir S. Pandeet. al. found that floating solar plants demonstrate an 11% increase in efficiency and can reduce water evaporation by up to 70%, their upfront costs are approximately 1.2% higher than those of conventional land-based solar installations. Nonetheless, regions in eastern, southern, and southeastern India—characterized by abundant water bodies—offer promising opportunities for deploying such systems. Implementing floating solar in these areas could redirect investments toward onshore infrastructure savings while simultaneously lowering electricity production costs, helping to bridge the disparity between thermal and solar energy generation [9].

The review also highlights that rooftop solar installations on residential homes typically range from 5 to 20 kW in capacity, while commercial buildings often have systems of 100 kW or more. On average, floating solar systems offer 11% higher capacity compared to traditional ground-mounted panels [10].

Dam Laila Zareefet. al. reveals that nearly 40% of water in open reservoirs is lost to evaporation. However, by covering just 30% of a reservoir's surface with photovoltaic panels, evaporation can be reduced by nearly 49%. With the global solar panel market surpassing 100 GW, a projected capacity of 104 GW indicates a steady annual growth rate of around 6% [11].The study assessed the feasibility of using floating solar panels for power generation and their effectiveness in reducing surface water evaporation on the Naghlo Dam.To evaluate this, researchers calculated the surface water evaporation rate in the Surobi district. These findings were then used to estimate both the potential reduction in evaporation achieved by deploying floating PV panels and the power generation capacity of the installed panels.

Figure 3: Average Monthly Evaporation From Free Surface Of Water In Surobi District [11]

The study concluded that surface water evaporation is at its peak in June, coinciding with an average of 11.7 hours of daily sunshine, while the lowest evaporation occurs during the winter month of December.

In total, the Surobi district of Kabul province experiences an annual surface water evaporation of approximately 2,839 mm. On average, around 34.5 million cubic meters of water evaporate each year from the Naghlo Dam reservoir.

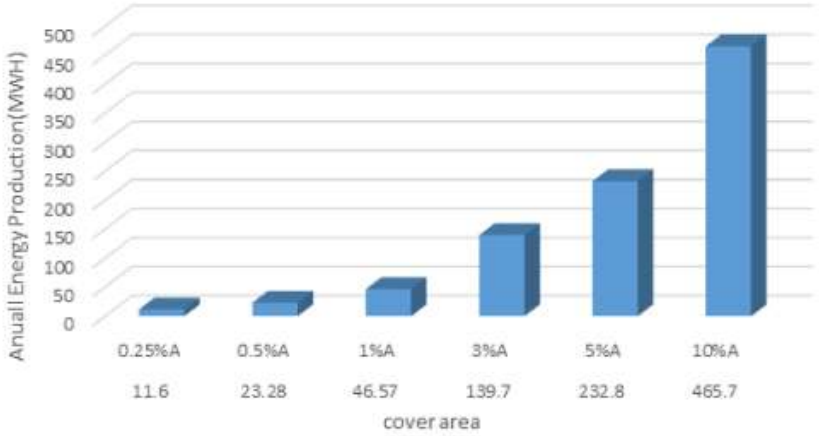

Figure 4: Annual Energy Generation Capacity Of Floating PV Panels System On Naghlo Dam [11]

The study found that covering just 3% of the Naghlo Dam reservoir with floating solar panels could generate 139.7 MWh of electricity annually—surpassing the current energy production capacity of the Naghlo hydropower plant, which is 100 MWh. This indicates an increase of 39.7 MWh beyond the dam's existing output. The integration of floating solar panels on the reservoir's surface could effectively raise the dam's capacity factor to 100%. Furthermore, if 10% of the reservoir surface were utilized for solar panel installation, the system could produce up to 467.7 MWh of electricity annually.

Dipen Paul et. al.conducted a project at a lake within the VishwairtiAgrotourism premises in Shirur, chosen for its on-site water body and ample sunlight—ideal conditions for generating continuous solar energy and determining the energy requirements of the project. Their findings indicated that floating photovoltaic (FPV) systems offer a cost-effective and space-saving alternative to traditional solar panel installations. Additionally, FPV technology enhances panel efficiency and is environmentally friendly, as it minimizes land usage. Notably, after just two hours of exposure to sunlight, the floating solar panels showed a 15.5% increase in power output compared to standard ground-mounted solar panels.

Figure 5: Floating Solar Power Plant Model [12]

Hongsubet. al. (2022)implemented a pivotless tracking-type floating solar power system installed at the Irwol Reservoir in Suwon, South Korea, and monitored for comparison between May 2019 and June 2020and compared its performance with that of a conventional fixed-type floating solar system.

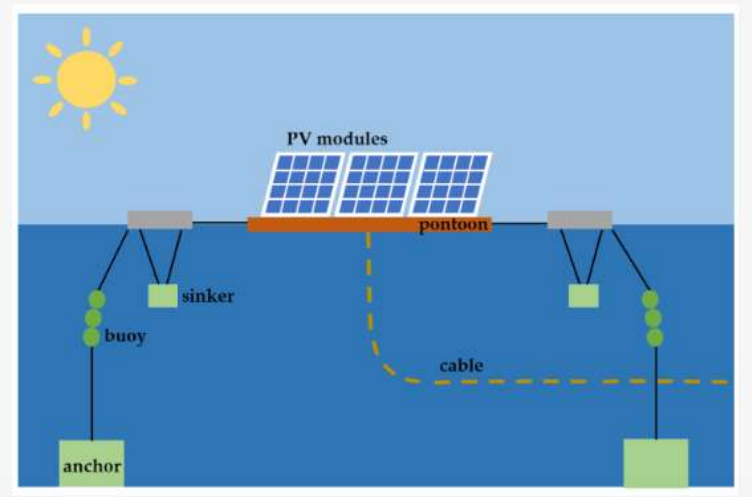

Figure 6: Layout of the Pivotless tracking type Floating Photovoltaic system [13]

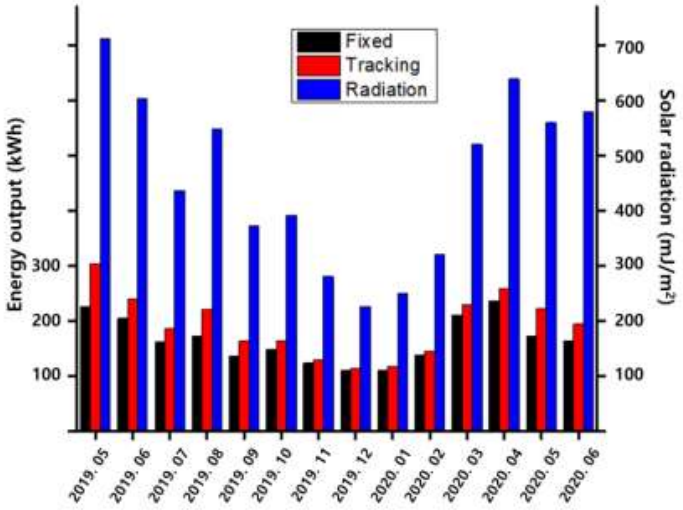

Figure 7: Comparison of monthly energy output of fixed and Tracking type solar power system with amount of Solar radiation [13]

The pivotless tracking system rotates throughout the day, allowing it to capture more sunlight and, consequently, generate more electricity. Over a 16-month observation period, this system produced approximately 14% more energy than the fixed-type system. The highest performance gain was recorded in May, with a 25.63% increase in energy output, while the lowest gain occurred during winter, showing only a 3% improvement. Due to its pivotless design, this tracking system is well-suited for large-scale floating solar installations, offering benefits such as lower construction costs, easier maintenance—by avoiding structural collisions with pylons—and safer operation under high wind conditions.

Floating photovoltaic (FPV) systems typically operate at temperatures 10–20°C lower than their ground-mounted counterparts, which can boost energy output by 2–10%, depending on the specific type of solar panel used. Recent innovations—such as foam-based floating racking structures—have also helped reduce installation costs to between $0.37 and $0.61 per watt, further enhancing the economic viability of FPV systems [14][15].

Benny Juniantoet. al.(2016)studied Development and Feasibility Analysis of Floating Solar Panel Application in Palembang, South Sumatra was conducted at Pier 12 Marine Pertamina, Palembang, Indonesia, from August 2–8, 2019. In this experiment, two 100 WP polycrystalline PV panels were installed—one on a floating system and one on the ground. Results showed that the floating panel's surface temperature was, on average, 2°C lower than the ground-mounted panel, reducing the risk of overheating. This temperature difference led to higher output power for the floating panel (51.6 watts) compared to the ground panel (42.9 watts), reflecting a 1.2% increase in efficiency. Acting as a

passive cooling system, the floating solar panel demonstrated superior performance over its ground-based counterpart [16].

The cooling effect from the proximity of water significantly lowers the operating temperature of photovoltaic (PV) modules, thereby enhancing their performance [18]. In addition to boosting efficiency, floating solar panels help conserve water by lowering water temperatures and minimizing the surface area exposed to evaporation. Studies indicate that these systems can reduce water evaporation by up to 33% on natural lakes and ponds, and by approximately 50% on artificial reservoirs and man-made facilities [19].

Mooring systems—essential for stabilizing vessels in deep-water operations—come in various configurations, including catenary, semi-taut, and taut systems. However, under severe environmental conditions, these systems may become unstable due to the influence of high waves and the dynamic behavior of vessels such as drillships [20]. In rough sea states, mooring line dynamics become increasingly complex, influenced by large wave-induced motions and viscous hydrodynamic effects. Over time, these factors reduce system reliability, with research indicating that mooring systems may fail to maintain station-keeping in highly unstable sea conditions [21, 22].

Numerous researchers have examined the dual impact of floating photovoltaic (FPV) systems on energy generation and the environment. When installed on water surfaces, FPVs offer environmental benefits such as reducing carbon emissions and conserving water by limiting surface evaporation [25,26,27]. In a study by Al-Widyan et al. [28], the environmental effects and energy efficiency of FPVs were investigated through water quality analysis. Using a spectrophotometer, water samples were collected between August 2020 and February 2021. The study found an overall improvement in water quality, evidenced by reduced algae biomass, lower pH levels at specific points, increased water clarity, and higher organic carbon content.

Performance-wise, floating PV systems generally outperform traditional land-based systems by over 10%. They are also capable of reducing water evaporation from reservoirs by approximately 70%. Despite these advantages, floating systems come with slightly higher upfront costs than conventional PV installations. Additionally, their long-term durability—particularly in saline environments—requires further study. Environmental factors like temperature and humidity can accelerate degradation processes in FPV systems, such as corrosion, fatigue of electrical ribbons, and hydrolysis of the back sheet material [29].

Comparison of Floating solar power plant and Conventional solar power plant
Advantages of Floating Solar Power Plants:

- **Higher Power Output:** Floating solar installations typically generate more electricity than traditional land-based solar systems.
- **Enhanced Efficiency:** The presence of water beneath the panels helps keep them cooler through evaporative cooling and reflected sunlight, leading to increased energy conversion efficiency.
- **Reduced Water Evaporation:** By shading the surface, floating solar panels significantly reduce water loss due to evaporation.
- **Improved Water Quality:** Decreased sunlight penetration can suppress algae growth and photosynthesis, thereby improving water quality.
- **Lower Dust Accumulation:** Floating systems are often less exposed to dust than ground-mounted systems, particularly in arid and dusty regions, contributing to better performance.
- **Land Conservation:** These systems preserve valuable land resources by utilizing otherwise unused water bodies, freeing land for agriculture, mining, tourism, and other land-intensive sectors.

Challenges of Floating Solar Power Plants:

- **High Initial Costs:** The upfront investment for installing floating solar plants is relatively high.
- **Increased Corrosion:** Exposure to water increases the risk of corrosion in metal components, potentially reducing system lifespan.
- **Reduced Light Penetration:** Blocking sunlight can negatively impact aquatic ecosystems by limiting the growth of aquatic plants and organisms.
- **Temperature-Related Efficiency Loss:** Lower humidity and temperatures around the panels can cause negative thermal drift, affecting performance.
- **Maintenance Needs:** Regular cleaning is required to remove sediment and clay that may accumulate along water edges.
- **Environmental Vulnerability:** The system is more exposed to natural threats such as storms, high tides, sea waves, cyclones, and tsunamis.
- **Disruption to Water Use:** Activities like fishing and water transportation may be impacted, depending on the plant's location.

CONCLUSION

This paper presents an overview of floating photovoltaic (FPV) systems deployed on calm water bodies such as ponds, lakes, dams, and reservoirs. In summary, the development of floating solar photovoltaic (FPV) systems presents a promising advancement in renewable energy generation. Utilizing water surfaces for solar installations not only optimizes land use but also offers added benefits such as reduced water evaporation and improved energy efficiency due to the cooling effect of water. While certain challenges remain—such as installation complexity and environmental impacts—the expanding research and increasing number of successful projects worldwide highlight the practicality and potential of FPV technology. As the pursuit of clean, sustainable energy accelerates globally, the adoption of floating solar systems marks a critical step toward addressing climate change and building resilient, future-ready energy infrastructures.It also offers a comparative analysis of installed FPV capacities globally. Based on the findings, the following conclusions have been drawn from the study.

- The average power capacity of a floating solar panel is 11%-15.5% more of the average capacity of a solar panel installed on the ground.
- FPV systems operate at lower average temperatures (10–20°C cooler), which enhances energy output by 2–10%, depending on the panel type.
- Water evaporation reduce by 70% and initial investment surpasses that of traditional solar power plants by 1.2%.
- Innovations such as foam-based floating racking systems have reduced costs,making FPV an increasingly economical option.
- Although, 40% of the water in open reservoirs is lost through evaporation,by covering only 30% of the water surface by FPV system, evaporation can be reduced by 49%.
- The pivotless tracking-type floating solar power system generated approximately 14% more energy than the fixed-type floating system.
- India's eastern, southern, and southeastern regions—including states like West Bengal, Assam, Odisha, Andhra Pradesh, Tamil Nadu, and Kerala—have abundant water bodies that offer significant potential for floating solar adoption. Implementing this technology in these areas could lead to substantial savings on land acquisition costs and reduce power generation expenses, thereby narrowing the cost gap between thermal and solar energy.
- The study demonstrated a general enhancement in water quality, marked by decreased algae biomass, reduced pH levels at certain locations, improved water transparency, and an increase in organic carbon levels.

Challenges

Despite their promising benefits, floating photovoltaic (FPV) systems face several challenges that need to be addressed. A primary concern is the relatively high cost of installation and ongoing maintenance. While traditional ground-mounted PV systems are still generally more cost-effective, FPV installations are exposed to challenging environmental factors such as wind, waves, and ultraviolet (UV) radiation, all of which can impact the system's durability and lifespan. Engineering design in this context is complex due to the need to account for factors such as fluctuating water levels, varying flow rates, wind speeds, the impact of waves, and the effects of mooring on sedimentation. Additionally, systems must manage trash and sediment effectively. Electrical components, in particular, must meet higher safety standards. Mooring and anchoring limitations are carefully considered. Comprehensive surveys and investigations—covering bathymetry, geotechnical conditions,seasonal flow patterns, water level fluctuations, as well as the volume and movement of debris and sediment—are essential. Moreover, there is a lack of standardization in material durability, testing procedures, certification processes, and institutional frameworks across the industry.

REFERENCES

[1]. Natarajan, S.K. et al., “Design and development of dual axis sun tracking system for floating PV plant” IOP Conference Series: Earth and Environmental Science, 312(1), 012001,2019. https://doi.org/10.1088/1755-1315/312/1/012001.

[2]. Abdurohman, K. and Adhitya, M, “Effect of water and seawater on mechanical properties of fiber reinforced polymer composites: a review for amphibious aircraft float development”, IOP Conference Series: Materials Science and Engineering, 694(1), 012035,2019.https://doi. org/10.1088/1757-899X/694/1/012035

[3]. Luo, W. et al.,“Performance loss rates of floating photovoltaic installations in the tropics. Solar Energy”, 219, 58–64,2021. Available at: https://doi. org/10.1016/J.SOLENER.2020.12.019.

[4]. Ramanan C.J., King Hann Lim, JundikaCandraKurnia, Sukanta Roy,,BhaskorJyoti Bora, BhaskarJyotiMedhi, “Towards sustainable power generation: Recent advancements in floating photovoltaic technologies”, Renewable and Sustainable Energy Reviews 194 (2024) 114322.https://doi.org/10.1016/j.rser.2024.114322

[5]. Yujia Wei, DanialKhojasteb, Christian Windt, Luofeng Huang, “An interdisciplinary literature review of floating solar power plants”, Renewable and Sustainable Energy Reviews 209 (2025) 115094

[6]. Jeffrey T. Dellosa, Ronieto N. Mendoza,RobertKerwin C. Billones, Yong Sheng,"Current Trends, Advancements, and Challenges in Floating Solar Photovoltaic (FSPV) Systems for Off-Grid Applications: A Review", J. Electrical Systems 20-5s (2024): 739-757

[7]. Prof. AniketDeshmukh, "An overview of Floating Solar Plants in Water bodies", VIVA-Tech International Journal for Research and Innovation ISSN(Online): 2581-7280 Volume 1, Issue 4 (2021)

[8]. Amer, Ayman; Attar, Hani; As'ad, Samer; Alsaqoor, Sameh; Colak, Ilhami; Alahmer, Ali; Alali, Malik; Borowski, Gabriel; Hmada, Moayyad; Solyman, Ahmed, "Floating photovoltaics: assessing the potential, advantages, and challenges of harnessing solar energy on water bodies" Published in: Journal of Ecological Engineering,(2023)

[9]. Prof. Shishir S. Pande, Prof.Vipashyana P. Athawale, Prof.Ujjwala.B.Malkhandale,Prof.DipaliD.Narwade, "A Paper on Floating Solar Power Plants: A Review", International Journal of Scientific Research in Engineering and Management (IJSREM) Volume: 08 Issue: 05 | May – 2024

[10]. HasnainYousuf, Muhammad QuddamahKhokhar, Muhammad AleemZahid,Jaeun Kim,YoungkukKim,Eun-ChelCho,Young Hyun Cho,Junsin Yi, "A Review on Floating Photovoltaic Technology (FPVT)" August 21, 2020, DOI: 10.21218/CPR.2020.8.3.067

[11]. Dam Laila Zareef, MarziaJalali, Sayed MoqeemSadat,"Analysis of the Potential for of Floating Solar Panels on Naghlo Hydropower", International Journal of Innovative Research and Scientific Studies, 4(2) 2021, pages: 126-132

[12]. Prof.NehaShridharraoDeshmukh,Mr.Om Sanjay Pasalkar,Mr.AtharvBhaskarHande, Mr.RohitParmeshwarSavatkar,Mr.Jayesh Manohar Kunjir,"Design & Study of Floating Solar Powerplant", International Journal of Creative Research Thoughts, Volume 11, Issue 5 May 2023

[13]. HongsubJee,YohanNoh,Minwoo Kim andJaehyeong Lee, "Comparing the Performance of Pivotless Tracking and Fixed-Type Floating Solar Power Systems", Appl. Sci. 2022, 12(24), 12926; https://doi.org/10.3390/app122412926

[14]. L. Essak and A. Ghosh, "Floating photovoltaics: A review," Clean Technologies, vol. 4, no. 3, pp. 752–769, 2022. [Online]. Available: https://doi.org/10.3390/CLEANTECHNOL4030046.

[15]. P. Mayville, N. V. Patil, and J. M. Pearce, "Distributed manufacturing of aftermarket flexible floating photovoltaic modules," Sustainable Energy Technologies and Assessments, vol. 42, p. 100830, 2020. [Online]. Available: https://doi.org/10.1016/J. SETA.2020.100830

[16]. Benny Junianto ,TresnaDewi , and Carlos R Sitompul, "Development and Feasibility Analysis of Floating Solar Panel Application in Palembang, South Sumatra",Journal of Physics: Conference Series 1500 (2020) 012016,doi:10.1088/1742-6596/1500/1/012016

[17]. Young-Kwan Choia, Nam-HyungLeea , An-KyuLeea , Kern-Joong Kim, "A study on major design elements of tracking-type floating photovoltaic systems",International Journal of Smart Grid and Clean Energy, vol. 3, no. 1, January 2014

[18]. AlokSahu , Neha Yadav, K. Sudhakar, "Floating photovoltaic power plant: A review",Renewable and Sustainable Energy Reviews,Volume 66, December 2016, Pages 815-824https://doi.org/10.1016/j.rser.2016.08.051

[19]. Choi Young-Kwan, "A study on power generation analysis of floating PV system considering environmental impact". Int J SoftwEngAppl 2014;8(1):75–84.

[20]. Paton, C.G., Carra, C.J., Sincock, P., "Investigation of sway/yaw motions of deepwater FPSOs" In Offshore Technology Conference, pp. OTC-18039,2006. https://doi.org/10.4043/18039-MS

[21]. Aghamohammadi, F., Thompson, J.M.T, "An experimental study of the large amplitude fish-tailing instabilities of a tanker at a single point mooring. Applied Ocean Research", 12(1): 25-33,1990. https://doi.org/10.1016/S0141-1187(05)80015-X

[22]. Bernitsas, M.M., Matsuura, J.O.P.J., "Revealing nonlinear dynamics phenomena in mooring due to slowly-varying drift". In International Conference on Offshore Mechanics and Arctic Engineering, 41952: 585-594,2005. https://doi.org/10.1115/OMAE2005-67289

[23]. https://testbook.com/ias-preparation/energy-crisis

[24]. https://mnre.gov.in/en/solar-overview/

[25]. Pimentel Da Silva, G.D.; Branco, D.A.C.,"Is floating photovoltaic better than conventional photovoltaic? Assessing environmental impacts". Impact Assess. Proj. Apprais. 2018, 36, 390–400. [Google Scholar] [CrossRef]

[26]. Rosa-Clot, P.,"FPV and Environmental Compatibility. In Floating PV Plants", Elsevier: Amsterdam, The Netherlands, 2020; pp. 101–118. [Google Scholar]

[27]. Exley, G.; Armstrong, A.; Page, T.; Jones, I.D,"Floating photovoltaics could mitigate climate change impacts on water body temperature and stratification". Solar Eng. 2021, 219, 24–33. [Google Scholar] [CrossRef]

[28]. Al-Widyan, M.; Khasawneh, M.; Abu-Dalo, M.,"Potential of floating photovoltaic technology and their effects on energy output, water quality and supply in Jordan". Energies 2021, 14, 8417. [Google Scholar] [CrossRef]

[29]. ErdemCuce, Pinar MertCuce, ShaikSaboor , Aritra Ghosh and YahyaSheikhnejad, "Floating PVs in Terms of Power Generation, Environmental Aspects, Market Potential, and Challenges",Sustainability 2022, 14, 2626. https://doi.org/10.3390/su14052626

[30]. Peipei Yang, Lloyd H. C. Chua, Kim N. Irvine,Manh Tuan Nguyen,E.-Wen Low, "Impacts of a foating photovoltaic system on temperature and water quality in a shallow tropical reservoir,"Limnology (2022) 23:441–454 https://doi.org/10.1007/s10201-022-00698-y